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Annita Lise
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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For	:	LIGHT COUPLING ELEMENT

Commissioner for Patents
Washington, D.C. 20231

Attention: Box Missing Parts

PRELIMINARY AMENDMENT

Sir:

Prior to examination, kindly amend the above-identified application, as follows:

IN THE SPECIFICATION:

Please amend the specification, as follows:

Page 1, line 1: after the Title, insert the following heading:

--Field and Background of the Invention--

Page 5, line 2: after the line, insert the following heading:

--Summary of the Invention--

Page 9, line 2: after the line, insert the following heading:

--Brief Description of the Drawings–

Page 10, line 1: after the line, insert the following heading:

--Description of the Preferred Embodiments–

IN THE CLAIMS:

Cancel Claims 1-23 inclusive.

Please add the following new Claims 24-84:

--24. A light coupling element having a surface (3) of a material which is transparent to light of a selected wavelength (λ), the element comprising: a first set of equidistantly parallel indentations (5_1) on at least one region of the surface (3); and a further set of equidistantly parallel indentations (5_2) on the surface (3) which intersect (φ) the first set of indentations (5_1).

25. A light coupling element with a surface (3) of a material which is transparent to light of a selected wavelength (λ), the element comprising: a first set of equidistantly parallel elevations (7_1) on at least one region of the surface (3); and a further set of equidistantly parallel elevations (7_2) on the surface (3) which intersect (φ) the first set of elevations (7_1).

26. A light coupling element as claimed in claim 25, including a first set of equidistantly parallel indentations (5_1) on at least one region of the surface (3) and a further set of equidistantly parallel indentations (5_2) on the surface (3) which intersect (φ) the first set of indentations (5_1), the indentations being between the elevations on the surface and having three depth levels (d_{T1}, d_{T2}, $d_{T1} + d_{T2}$).

27. A light coupling element as claimed in claim 25, including indentations (5, 5_1, 5_2) disposed between the elevations (7, 7_1, 7_2) and being substantially of equal depth.

28. A light coupling element as claimed in claim 24, wherein the indentations (5_1, 5_2) are linear.

29. A light coupling element as claimed in claim 25, wherein the elevations (7_1, 7_2) are linear.

30. A light coupling element as claimed in claim 24, wherein the first and further sets of indentations (5_1, 5_2) are linear and intersect at right angles and the distances (d_0) of successive equidistantly parallel indentations (5_1, 5_2) are equal.

31. A light coupling element as claimed in claim 25, wherein the first abd further sets of elevations (7_1, 7_2) are linear and intersect at right angles and the distances (d_0) of successive equidistantly parallel elevations (7_1, 7_2) are equal.

32. A light coupling element as claimed in claim 24, wherein distances (d_0) of successive equidistantly parallel indentations (5_1, 5_2) are selected as follows:

$$200 \text{ nm} \leq d_0 \leq 20000 \text{ nm}.$$

33. A light coupling element as claimed in claim 24, wherein distances (d_0) of successive equidistantly parallel indentations (5_1, 5_2) are selected as follows:

$$40 \text{ nm} \leq d_0 \leq 4000 \text{ nm}.$$

34. A light coupling element as claimed in claim 24, wherein distances (d_0) of successive equidistantly parallel indentations (5_1, 5_2) are selected as follows:

$$100 \text{ nm} \leq d_0 \leq 1200 \text{ nm}.$$

35. A light coupling element as claimed in claim 25, wherein distances (d_0) of successive equidistantly parallel elevations (7_1, 7_2) are selected as follows:

$$200 \text{ nm} \leq d_0 \leq 20000 \text{ nm}.$$

36. A light coupling element as claimed in claim 25, wherein distances (d_0) of successive equidistantly parallel elevations (7_1, 7_2) are selected as follows:

$$40 \text{ nm} \leq d_0 \leq 4000 \text{ nm}.$$

37. A light coupling element as claimed in claim 25, wherein distances (d_0) of successive equidistantly parallel elevations (7_1, 7_2) are selected as follows:

$$100 \text{ nm} \leq d_0 \leq 1200 \text{ nm}.$$

38. A light coupling element as claimed in claim 24, wherein the distances (d_0) of successive equidistantly parallel indentations (5_1, 5_2) relative to the selected wavelength λ in air are selected as follows:

$$0.1\,\lambda \leq d_0 \leq 10\,\lambda.$$

39. A light coupling element as claimed in claim 24, wherein the distances (d_0) of successive equidistantly parallel indentations (5_1, 5_2) relative to the selected wavelength λ in air are selected as follows:

$$0.2\,\lambda \leq d_0 \leq 2\,\lambda.$$

40. A light coupling element as claimed in claim 24, wherein the distances (d_0) of successive equidistantly parallel indentations (5_1, 5_2) relative to the selected wavelength λ in air are selected as follows:

$$0.5\,\lambda \leq d_0 \leq 0.6\,\lambda.$$

41. A light coupling element as claimed in claim 25, wherein the distances (d_0) of successive equidistantly parallel (7_1, 7_2) relative to the selected wavelength λ in air are selected as follows:

$$0.1\,\lambda \leq d_0 \leq 10\,\lambda.$$

42. A light coupling element as claimed in claim 25, wherein the distances (d_0) of successive equidistantly parallel (7_1, 7_2) relative to the selected wavelength λ in air are selected as follows:

$$0.2\,\lambda \leq d_0 \leq 2\,\lambda.$$

43. A light coupling element as claimed in claim 25, wherein the distances (d_0) of successive equidistantly parallel (7_1, 7_2) relative to the selected wavelength λ in air are selected as follows:

$$0.5\,\lambda \leq d_0 \leq 0.6\,\lambda.$$

44. A light coupling element as claimed in claim 24, wherein the depth d_T of the indentations is 0.2 nm to 20000 nm.

45. A light coupling element as claimed in claim 24, wherein the depth d_T of the indentations is 10 nm to 400 nm.

46. A light coupling element as claimed in claim 24, wherein the depth d_T of the indentations relative to the selected wavelength λ in air is selected as follows:

$$0.001\ \lambda \leq d_T \leq 10\ \lambda.$$

47. A light coupling element as claimed in claim 24, wherein the depth d_T of the indentations relative to the selected wavelength λ in air is selected as follows:

$$0.01\ \lambda \leq d_T \leq \lambda.$$

48. A light coupling element as claimed in claim 24, wherein the depth d_T of the indentations relative to the selected wavelength λ in air is selected as follows:

$$0.05\ \lambda \leq d_T \leq 0.2\ \lambda.$$

49. A light coupling element as claimed in one of claim 24, wherein a duty cycle, defined as the ratio of elevation width to the distance of successive indentations, is selected to be 0.2 to 0.8.

50. A light coupling element as claimed in one of claim 24, wherein a duty cycle, defined as the ratio of elevation width to the distance of successive indentations, is selected to be 0.4 to 0.6.

51. A light coupling element as claimed in claim 25, wherein a duty cycle, defined as the ratio of elevation width to the distance of successive elevations, is selected to be 0.2 to 0.8.

52. A light coupling element as claimed in claim 25, wherein a duty cycle, defined as the ratio of elevation width to the distance of successive elevations, is selected to be 0.4 to 0.6.

53. A light coupling element as claimed in claim 24, wherein the surface (3) is the surface of a layer system (1a) with at least one layer which is applied onto a support (15).

54. A light coupling element as claimed in claim 51, wherein the surface of the support (15) in the region has the same indentation structure as the surface of the layer system (1a) and that, in top view, the structures are aligned one on another.

55. A light coupling element as claimed in claim 51, wherein the material of the support (15) has a refractive index for the light of the selected wavelength (λ) which is lower than the refractive index of a layer material of the layer system.

56. A light coupling element as claimed in claim 51, wherein the layer system has at least one layer of a high-refractive material.

57. A light coupling element as claimed in claim 54, wherein the high-refractive material is at least one of the following materials: Ta_2O_5, TaO_2, NbO_5, ZrO_2, ZnO, HfO_2.

58. A light coupling element as claimed in claim 51, wherein the layer system has a thickness d_S of 2 nm to 20000 nm.

59. A light coupling element as claimed in claim 51, wherein the layer system has a thickness d_S of 20 nm to 4000 nm.

60. A light coupling element as claimed in claim 51, wherein the layer system has a thickness d_S of 40 nm to 600 nm.

61. A light coupling element as claimed in claim 51, wherein the layer system has a thickness d_S of 150 nm.

62. A light coupling element as claimed in claim 51, wherein the layer system, relative to the selected wavelength λ in air, has a thickness d_S for which, relative to the selected wavelength λ, in air applies:

$$0.01\,\lambda \le d_S \le 10\,\lambda.$$

63. A light coupling element as claimed in claim 51, wherein the layer system, relative to the selected wavelength λ in air, has a thickness d_S for which, relative to the selected wavelength λ, in air applies:

$$0.01\,\lambda \le d_S \le 2\,\lambda.$$

64. A light coupling element as claimed in claim 51, wherein the layer system, relative to the selected wavelength λ in air, has a thickness d_S for which, relative to the selected wavelength λ, in air applies:

$$0.2\,\lambda \leq d_S \leq 0.3\,\lambda.$$

65. A light coupling element as claimed in claim 25, wherein the surface (3) is the surface of a layer system (1a) with at least one layer, which is applied onto a support (15).

66. A light coupling element as claimed in claim 63, wherein the surface of the support (15) in the region has the same elevation structure as the surface of the layer system (1a) and that, in top view, the structures are aligned one on another.

67. A light coupling element as claimed in claim 63, wherein the material of the support (15) has a refractive index for the light of the selected wavelength (λ) which is lower than the refractive index of a layer material of the layer system.

68. A light coupling element as claimed in claim 63, wherein the layer system has at least one layer of a high-refractive material, preferably of at least one of the following materials: Ta_2O_5, TaO_2, NbO_5, ZrO_2, ZnO, HfO_2.

69. A light coupling element as claimed in claim 63, wherein the layer system has a thickness d_S of 2 nm to 20000 nm.

70. A light coupling element as claimed in claim 63, wherein the layer system has a thickness d_S of 20 nm to 4000 nm.

71. A light coupling element as claimed in claim 63, wherein the layer system has a thickness d_S of 40 nm to 600 nm.

72. A light coupling element as claimed in claim 63, wherein the layer system has a thickness d_S of 150 nm.

73. A light coupling element as claimed in claim 63, wherein the layer system, relative to the selected wavelength λ in air, has a thickness d_S for which, relative to the selected wavelength λ, in air applies:

$$0.01\ \lambda \leq d_S \leq 10\ \lambda.$$

74. A light coupling element as claimed in claim 63, wherein the layer system, relative to the selected wavelength λ in air, has a thickness d_S for which, relative to the selected wavelength λ, in air applies:

$$0.01\ \lambda \leq d_S \leq 2\ \lambda.$$

75. A light coupling element as claimed in claim 63, wherein the layer system, relative to the selected wavelength λ in air, has a thickness d_S for which, relative to the selected wavelength λ, in air applies:

$$0.2\ \lambda \leq d_S \leq 0.3\ \lambda.$$

76. A light coupling element as claimed in claim 24, including elevations (7) between the equidistantly parallel indentations (5_1, 5_2) in top view being rhomboid, rhombus, rectangular or square.

77. A light coupling element as claimed in claim 25, including indentations (5) between the equidistantly elevations (7_1, 7_2) in top view being rhomboid, rhombus, rectangular or square.

78. A light coupling element as claimed in claim 25, including indentations (5) between the parallel elevations (7_1, 7_2) in top view being circular or elliptic.

79. A light coupling element as claimed in claim 24, on an optical analysis platform for substance analyses.

80. A light coupling element as claimed in claim 25, on an optical analysis platform for substance analyses.

81. A light coupling element as claimed in claim 24 in combination with a telecommunication data transmission apparatus.

82. A light coupling element as claimed in claim 25 in combination with a telecommunication data transmission apparatus.

83. A method for realizing polarization independence by means of which a light coupling element with a surface grating acts onto incident light of selected wavelength, comprising: developing the surface grating to be two-dimensionally on the surface such that orthogonal polarization vector components are influenced equally by the grating.

84. A method for reducing a drop size on a light coupling element with surface grating, comprising: providing a surface grating extending in two dimensions so that the drop size developing thereon is reduced. –

REMARKS

Claims 24-84 are in the case and presented for consideration.

There are a total of 61 claims, with 4 being independent. A check in the amount of $768.00 is enclosed to cover the 38 additional dependent claims, including 1 additional independent claim now present. Applicants have previously paid for 23 total claims with 3 being independent.

Multiple dependent claims have been avoided and the claims have been placed in better form for examination.

Entry of this amendment, and favorable action is respectfully requested.

Respectfully submitted,

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Patent

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LIGHT COUPLING ELEMENT

Field and Background of the Invention

The present invention relates to a light coupling element with ~~a~~ surface comprised of a material which is transparent to light of a given wavelength, wherein in at least one region of the surface a line grating is present with equidistant parallel line-form indentations or with equidistant parallel line-form elevations.

The present invention builds primarily on findings which were obtained on light coupling elements of said type to demonstrate chemical or biochemical reactions in conjunction with fluorescence. In this respect reference is made in particular to WO 01/02839, wherein within the scope of an analysis platform such a light coupling element is described. An effect, known as "abnormal reflection" is utilized. Therein a support provided with a layer is provided. This support, and also the layer, is preferably transparent to light of a given wavelength λ in the UV VIS or NIR range (200 nm to 2000 nm) of a light source, preferably of an at least approximately monochromatic light source, such as for example of a laser or an LED. In the case of dielectric material, the material of the layer has a substantially higher refractive index than the material of the support, viewed at the given wavelength. The surface of the support, on which the layer is placed, has a line grating, whose structure is transferred via the thin layer to the surface of the layer. In the utilized "abnormal reflection effect" light of the given wavelength is virtually completely reflected when a specific angle of incidence is maintained and virtually no light is transmitted along the layer or through the layer. With suitable selection of the structure parameters the evanescent, *i.e.* transversely damped, electromagnetic field in the immediate vicinity of the layer surface becomes especially strong, whereby fluorescence molecules are especially efficiently excited in this region. This permits detecting substantially lower concentrations of substances provided with

increasingly contracts until the effect is reached utilized according to EP 1 040 874, that namely the liquid drops off the observed region.

Summary of the Invention

In the light coupling element according to the present invention the specific surface is increased in the observed region, compared to the case in which only one line grating is provided, but only so far that while a drop placed thereon contracts, it does, however, not drop off. In the above preferred application of the light coupling element according to the invention for generating evanescent, *i.e.* transversely damped, electromagnetic fields within the scope of a technique such as is prior known, for example from WO 01/02839, thereby an increased concentration results of an applied liquid substance, provided with labels, on the surface, which, in turn, increases the resulting fluorescence signal which can be read out and, additionally, entails the advantage that in the region considered a majority, even a multitude, of discrete liquid drops can be deposited without these merging into one another.

In a preferred embodiment of the light coupling element according to the invention it is proposed to provide indentations having three levels of depth.

By the staggering in the depth of the indentations, an additional parameter is provided for varying the size of said specific surface.

It must be taken into consideration that inwardly projecting side areal parts of said indentations also determine said specific surface, and that deeper indentations increase said specific surface more than shallower indentations.

In a further preferred embodiment of the inventive light coupling element the indentations are substantially of equal depth everywhere.

Even though the equidistantly parallel line-form indentations or elevations provided

preferably

$$2 \text{ nm} \leq d \leq 100 \text{ nm}.$$

Brief Description of the Drawings

In the following the invention will be explained by examples in conjunction with Figures. Therein depict:

Fig. 1 schematically and in top view a light coupling element of known type with one-dimensional line grating,

Fig. 2 in a representation analogous to that of Figure 1 in top view and with two sectional representations, a first preferred embodiment of a light coupling element according to the invention,

Fig. 3 in top view representation analogous to that of Figure 2 a further embodiment of a light coupling element according to the invention,

Fig. 4 (a) and 4 (b) schematically the effect of the surface structuring on the formation of a drop of liquid placed onto the surface,

Fig. 5 in conjunction with a top view representation in analogy to Figures 2 or 3, a light coupling element according to the invention with indentations at three different indentation depth levels,

Fig. 6 a preferred embodiment of a light coupling element according to the invention in schematically perspective representation and realized according to the embodiment of Figure 2, and

Fig. 7 in a representation analogous to that of Figure 6, a light coupling element

realized according to the embodiment of Figure 3.

Description of the Preferred Embodiments

In Figure 1, on one hand in top view, on the other hand in a side view is shown a line grating of prior art. A line grating is worked into the surface 3 of a material transparent to light of a given wavelength, in particular for laserlight of wavelength λ = 633 nm, such as for example of Ta_2O_5. The line grating comprises indentations 5 which are parallel to one another, and, if light of a single wavelength λ is to be incident on it, preferably with 200 nm $\leq \lambda \leq$ 2000 nm, and the indentations 5 are equidistant in the sense that their distances d_0 are identical everywhere as well as their width d_5 and thus the width d_7 of the webs 7 remaining between the indentations 5. The distances d_0 define the grating period, as is readily evident based on the side view, with the duty cycle of the grating defined as the ratio of the elevation width d_7 to the grating period d_0.

The depth d_T of the indentations is conventionally also identical everywhere. The material of the surface 3 and of the body 1, the grating period d_0, the duty cycle of the grating and the grating depth d_T are therein adapted to the desired light wavelength λ.

The line grating, depicted in Figure 1 and known per se can optionally also be arcuate, as shown in dot-dash lines. It defines a direction of progression LG_1. If this direction in the original surface plane *E* not provided with the indentations 7, is defined as y, and the direction transversely to it, as shown, as x, the following is evident: as shown schematically with light beam 9, the components E_x and E_y of a vectorial parameter *E* of the light, such as in particular its polarization, are affected differently by the line grating, i.e. the effect of the line grating with respect to such vectorial parameters of the light depends on the vector direction α. For example, the effect of the line grating is not independent of the direction of polarization of the light in the light beam 9.

As was already explained in the introduction, it is prior known to treat light of two and more wavelengths λ with line gratings of the type shown in Figure 1. For this purpose,